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**JP 2002010362 A** **US 6038452 A**
**US 20010019589 A1**

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Other:

(54) Abstract Title: **A communication network and method of setting an error rate therefor**

(57) The invention relates to a system for setting an error rate of a radio link supporting wireless user equipment in a cellular communications system, which communicates with an endpoint terminal; comprises an error processor, to determine error characteristics information associated with the communication link; connected to an error controller which sets the error rate of the radio link in response to the determined error characteristics information. The error rate is set such that an overall error rate between the wireless user equipment and the endpoint terminal meets the criterion that the overall error rate, on average, is below a given threshold. Preferably, the characteristics information relates to whether the communication link includes a second radio link or not. If not, the error rate is set approximately twice as high as when a second radio link is included. The external network may be a TIPHON network, and Transcoder Free Operation or Tandem Free Operation may also be used for communication between the wireless equipment and the endpoint terminal.

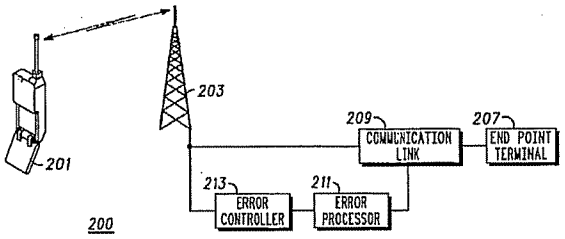


*FIG. 2*

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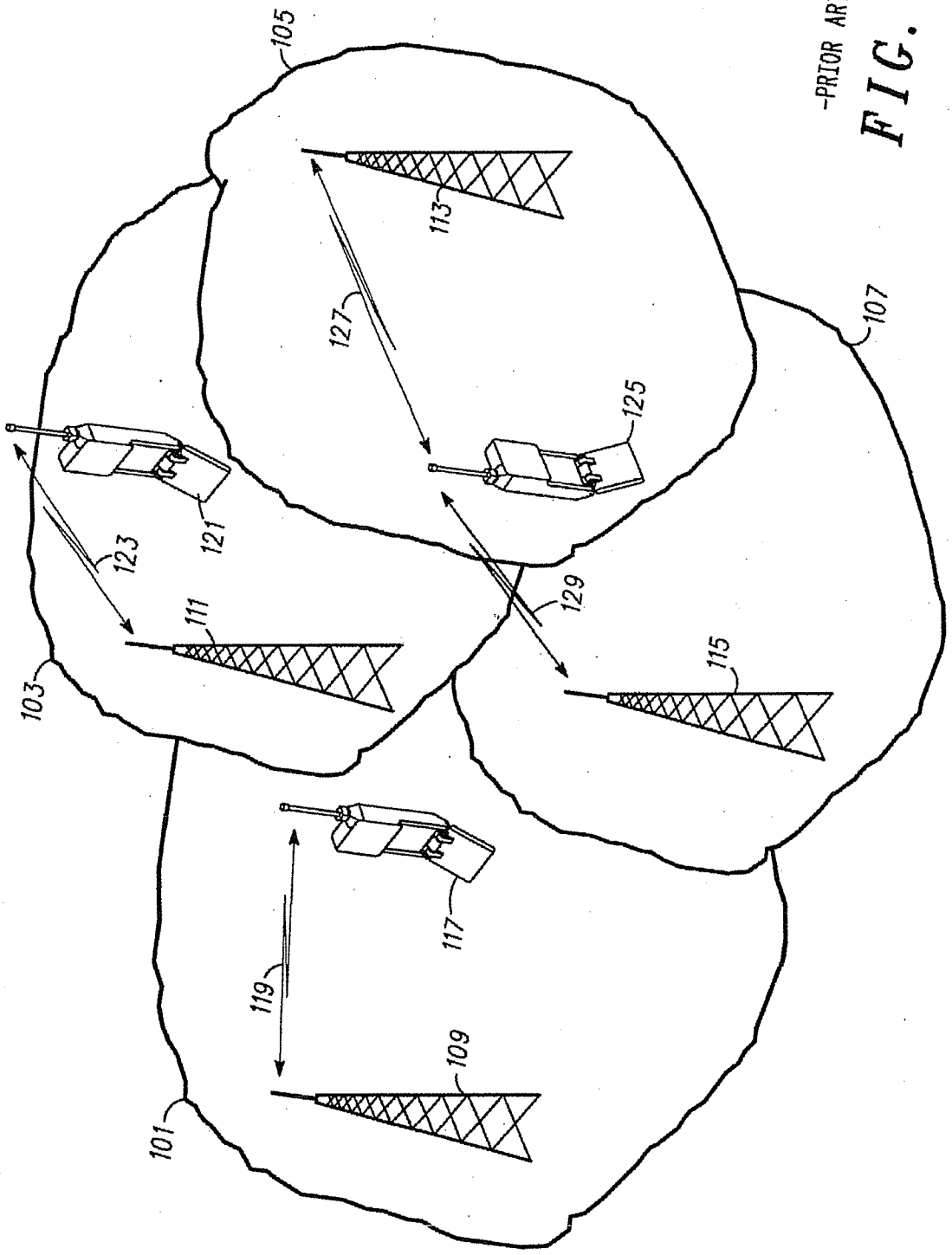
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.




-PRIOR ART-

FIG. 1

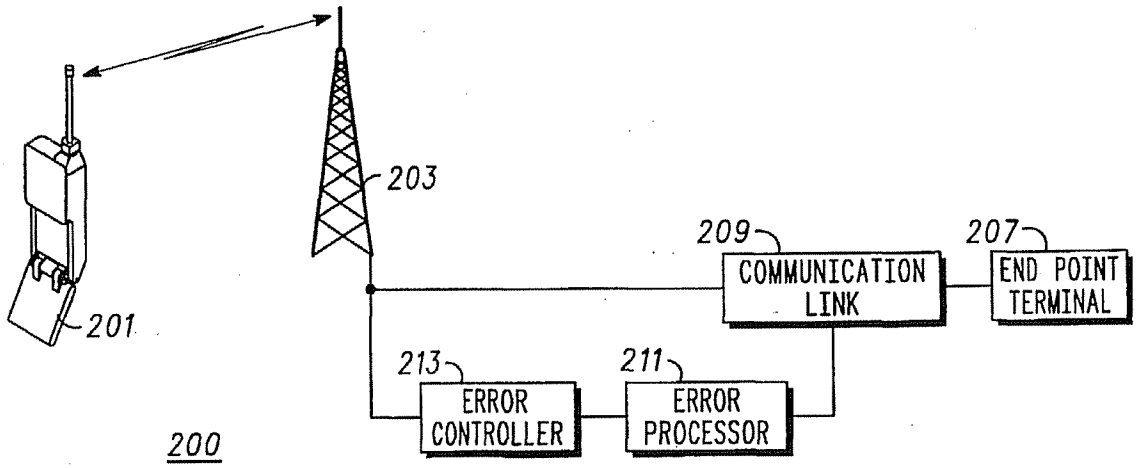

203
209
COMMUNICATION LINK
207
END POINT TERMINAL
201
213
ERROR CONTROLLER
211
ERROR PROCESSOR
200

FIG. 2

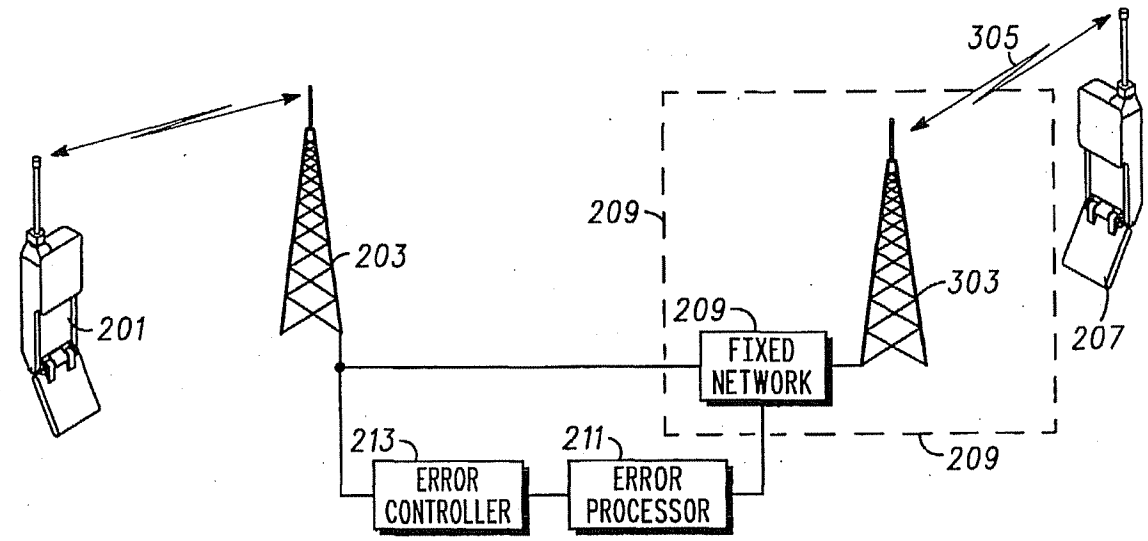

305
209
203
303
209
FIXED NETWORK
207
201
213
ERROR CONTROLLER
211
ERROR PROCESSOR
209

FIG. 3

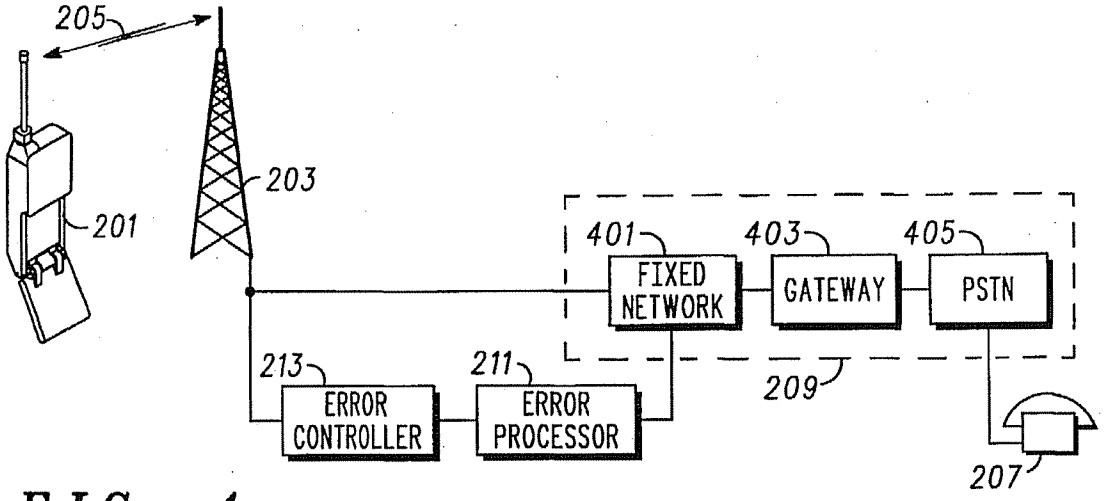

205
203
201
401
403
405
FIXED NETWORK
GATEWAY
PSTN
213
211
ERROR CONTROLLER
ERROR PROCESSOR
209
207

FIG. 4

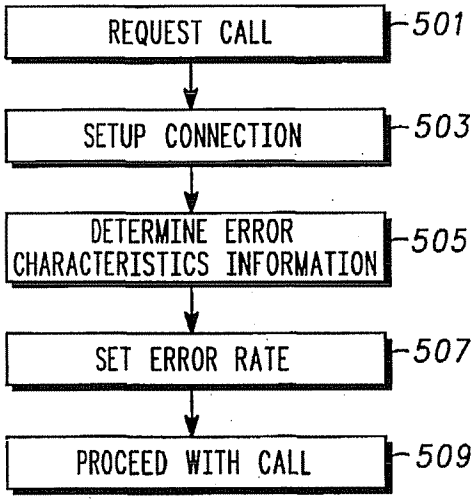

REQUEST CALL
501
SETUP CONNECTION
503
DETERMINE ERROR CHARACTERISTICS INFORMATION
505
SET ERROR RATE
507
PROCEED WITH CALL
509

FIG. 5

# A COMMUNICATION NETWORK AND METHOD OF SETTING AN ERROR RATE THEREFOR

## Field of the invention

The invention relates to a communication network and method of setting an error rate therefor, and in particular to a communication network and method for a cellular communication system.

## Background of the Invention

FIG. 1 illustrates the principle of a conventional cellular communication system 100 in accordance with prior art. A geographical region is divided into a number of cells 101, 103, 105, 107 each of which is served by base station 109, 111, 113, 115. The base stations are interconnected by a fixed network which can communicate data between the base stations 101, 103, 105, 107. A mobile station is served via a radio communication link by the base station of the cell within which the mobile station is situated. In the example if FIG. 1, mobile station 117 is served by base station 109 over radio link 119, mobile station 121 is served by base station 111 over radio link 123 and so on.

As a mobile station moves, it may move from the coverage of one base station to the coverage of another, i.e. from one cell to another. For example mobile station 125 is initially served by base station 113 over radio link 127. As it moves towards base station 115 it enters a region of overlapping coverage of the two base stations 111 and 113 and within this overlap region it changes to be supported by base station 115 over radio link 129. As the mobile station 125 moves further into cell 107, it

continues to be supported by base station 115. This is known as a handover or handoff of a mobile station between cells.

A typical cellular communication system extends coverage over typically an entire country and comprises hundred or even thousands of cells supporting thousands or even millions of mobile stations. Communication from a mobile station to a base station is known as uplink, and communication from a base station to a mobile station is known as downlink.

The fixed network interconnecting the base stations is operable to route data between any two base stations, thereby enabling a mobile station in a cell to communicate with a mobile station in any other cell. In addition the fixed network comprises gateway functions for interconnecting to external networks such as the Public Switched Telephone Network (PSTN), thereby allowing mobile stations to communicate with landline telephones and other communication terminals connected by a landline. Furthermore, the fixed network comprises much of the functionality required for managing a conventional cellular communication network including functionality for routing data, admission control, resource allocation, subscriber billing, mobile station authentication etc.

The frequency band allocated for a cellular communication system is typically severely limited, and therefore the resource must be effectively divided between mobile stations. A fundamental property of a cellular communication system is that the resource is divided geographically by the division into different cells. Thus a certain amount of resource (for example a frequency band) may at a given time be allocated to a given cell thereby reducing the resource allocation to neighbouring cells. In order to optimise the capacity of a cellular communication system, it is important to minimise the impact of interference caused by or to other mobile stations. An important advantage of a cellular communication system is

that due to the radio signal attenuation with distance, the interference caused by communication within one cell is negligible in a cell sufficiently far removed, and therefore the resource can be reused in this cell. In addition, the resource is typically divided within one cell and between cells by division of the resource in the time domain, the frequency domain and/or the code domain. Different communication systems use different principles for this division. The resource allocation may be static or dynamic dependent on the current load of the communication system, and typically a combination of static and dynamic resource allocation is used.

First generation analogue communication systems use a frequency division multiple access (FDMA) system, where the frequency domain is used for dividing the resource between cells. In these systems, the frequency band is divided into narrowband channels of typically 25 kHz bandwidth. A number of these channels are allocated to each base station and upon call setup each mobile station will be allocated a specific narrowband channel for uplink communication and one for downlink communication.

Currently the most ubiquitous cellular communication system is the 2nd Generation system known as the Global System for Mobile communication (GSM). Similarly to analogue systems, the frequency band is divided into relatively narrow channels of 200 kHz and each base station is allocated one or more of these frequency channels. However, in contrast to the analogue systems, each frequency channel is divided into eight separate time slots allowing up to eight mobile stations to use each frequency channel. This method of sharing the available resource is known as Time Division Multiple Access (TDMA). Further description of the GSM TDMA communication system can be found in 'The GSM System for Mobile Communications' by Michel Mouly and Marie Bernadette Pautet, Bay Foreign Language Books, 1992, ISBN 2950719007.

Another principle of resource distribution is employed in the 2nd generation system known as IS95, as well as in 3rd Generation systems such as the Universal Mobile Telecommunication System (UMTS). These systems divide the frequency into one or few wide band channels, which for UMTS has a bandwidth of 5 MHz. Typically, one wide band frequency channel is used for uplink in all cells and a different wide band frequency channel is used for downlink. In this case, separation between cells is achieved through the use of spread spectrum techniques, where each cell is allocated a cell specific long user spreading code.

In these systems, a signal to be transmitted is multiplied by the spreading code, which has a chip rate typically much larger than the data rate of the signal. Consequently, a narrowband signal is spread over the wideband frequency channel. In the receiver, the received signal is multiplied by the same spreading code thereby causing the original narrowband signal to be regenerated. However, signals from other cells having a different spreading code are not despread by the multiplication in the receiver, and remain wideband signals. The majority of the interference from these signals can consequently be removed by filtering of the despread narrowband signal, which can then be received.

Separation between mobile stations of the same cell is also achieved by use of spread spectrum techniques. The signal to be transmitted is multiplied by a shorter user specific code. Similarly, the receiver multiplies the received signal with the user specific code, thereby recovering the originally transmitted signal without despreading signals from any of the other mobile stations. Thus, the interference from all other mobile stations, whether in the same or a different cell, can effectively be reduced by filtering.

A consequence of the spread spectrum techniques employed is that the amount of the interfering spread signals, which fall within the bandwidth

of the narrowband signal cannot be removed by filtering, and will thus reduce the signal to interference ratio of the received signal. Consequently, it is of the outmost importance that the interference between mobile stations is optimised in order to maximise the capacity of the system. The reduction of the interference from an unwanted mobile station is equal to the ratio between the bandwidth of the spread signal and the narrowband despread signal, equivalent to the ratio between the chip rate and the symbol rate of the transmitted signal. This ratio is known as the processing gain. The technique is known as Code Division Multiple Access (CDMA), and further description of CDMA and specifically of the Wideband CDMA (WCDMA) mode of UMTS can be found in 'WCDMA for UMTS', Harri Holma (editor), Antti Toskala (Editor), Wiley & Sons, 2001, ISBN 0471486876.

A different principle of dividing the available frequency resource is used in a different mode of UMTS, known as the Time Division Duplex (TDD) mode. Similarly to WCDMA, the frequency band is divided into few wide band frequency channels. As for WCDMA, the same wide band frequency channel is typically used in all cells, and cell separation is achieved by each cell having a cell specific spreading code. However, in contrast to WCDMA, the same frequency band is used for uplink and downlink signals. In TDD the wide band frequency channel is divided into 16 time slots, which can be allocated to uplink or downlink signals. Up to eight mobile stations can be allocated in each time slot, and separation between these is achieved by each mobile station being allocated a short user specific code. In contrast to CDMA, the user specific code and time slot interval are sufficiently low to allow joint detection of all signals within each time slot to be performed, thereby significantly reducing the interference between mobile stations. A different but similar TDD system is the 3rd generation cellular communication system known as Time Division Synchronous Code Division Multiple Access (TD-SCDMA).

Common for all types of cellular communication systems is that it is imperative to manage the radio links between the base stations such that the resource used by a given communication link is as low as possible. Thus, it is important to minimise the interference caused by the communication to or from a mobile station, and consequently it is important to use the lowest possible transmit power. As the required transmit power depends on the instantaneous propagation conditions, it is necessary to dynamically control transmit powers to closely match the conditions. For this purpose, the base stations and mobile stations operate power control loops, where the receiving end reports information on the receive quality back to the transmitting end, which in response adjusts it's transmit power.

Specifically, in WCDMA, the downlink power control operates by the mobile station reporting the error rate of the received signal, and the base station decreasing the transmit power, if this rate is below a desired downlink error threshold, and increasing it otherwise. In the uplink direction, the base stations measure the received error rate and compare it to an uplink error threshold. If the error rate is below the threshold, it transmits a power down control signal to the mobile station, and if above the threshold it transmits a power up threshold.

In WCDMA, both an inner power control loop and an outer power control loop is implemented. Inner loop power control operates as follows. The receiving entity of a radio link measures the received signal to noise ratio (SIR), and compares it to a locally stored target SIR. A command is sent back to the transmitter to increase transmitted power if the measured SIR is less than the target. Conversely, if the measured SIR is greater than the target, a command is sent to the transmitter to decrease the transmitted power. The target SIR is set by a known feature called outer loop power control. Its function is to maintain the frame error rate (FER) of the radio link at or below a given value or threshold. The frame error rate of the

received signal is measured by one of a number of known techniques, and the SIR target is adjusted to try to ensure that the FER is at or below the given value.

It is clear, that the lower the error thresholds are set, the higher the transmit power will be and thus the higher the interference to other mobile stations. Thus the resource used by the communication with the mobile station increases for decreasing thresholds, and therefore the error thresholds are set as high as possible, whilst still providing the required quality of service. The quality of service required for the radio link will depend on the service required and may range from a relatively high error rate for voice communication to a very low data rate for high reliability data calls.

Existing algorithms for setting the error threshold for the radio link comprise determining which service is requested, and setting the quality of the service parameters to a predetermined value dependent only on the service type and the propagation characteristics of the radio link itself. However, these algorithms only take account of the service type and the radio link propagation characteristics, and do not consider any other dynamic conditions or characteristics of the communication system. Consequently, they tend to be inefficient and result in either unreliable communication, because the error thresholds are set too high, or more often in wasting resource as the thresholds are set to low.

An improvement in setting an error rate for the radio link in a cellular communication system is therefore desirable.

## Summary of the Invention

The inventors of the present invention have realised that improvements in the error rate setting for a radio link in a cellular communication system can be achieved by considering characteristics and conditions of the cellular communication system. Accordingly, the current invention seeks to improve the setting of the error rate by considering the error characteristics of a communication link to an endpoint terminal.

Accordingly there is provided a method of setting an error rate in a cellular communication system supporting wireless user equipment over a radio link for communication with an endpoint terminal, the method comprising the steps of: determining error characteristics information associated with a communication link to the endpoint terminal; and setting an error rate of the radio link in response to the determined error characteristics information associated with the communication link.

The invention thus provides a method wherein the error rate setting of a radio link supporting a user equipment can be optimised by taking the error characteristics of the communication link to the endpoint terminal into account. Consequently, the resource usage of the radio link is minimised, thereby optimising the capacity of the communication system. In other words, a better or more optimal compromise between achieving an adequate quality of service and minimising resource (e.g power) consumption.

According to one feature of the invention, the step of setting the error rate comprises setting the error rate of the radio link such that an overall error rate between the wireless user equipment and the endpoint terminal meets a given criterion, preferably that the overall error rate on average is below a given threshold.

This provides the advantage of the error rate being set so that the overall communication achieves the desired error rate, while maintaining a minimum of resource usage.

According to a second feature of the invention, the error characteristics information comprises information of whether the communication link includes a second radio link.

The majority of errors in a communication are due to errors over radio links, and therefore determining if a second radio link is involved in the communication is a low complexity method for determining error characteristics information suitable for setting an optimal data rate.

According to a third feature of the invention, the step of determining error characteristics information of the communication link comprises the step of determining if the endpoint terminal is a wireless user equipment supported over the second radio link.

In many situations, it is possible to determine if the endpoint terminal is a wireless user equipment, and this provides a simple yet efficient method of determining if a second radio link is involved.

According to a fourth feature, the step of setting the error rate comprises setting the error rate of the radio link at a lower error rate when the communication link includes the second radio link and at a higher error rate when the communication link does not include the second radio link, and preferably the higher error rate is substantially twice the lower error rate.

This has the advantage being simple to implement yet efficiently guaranteeing an acceptable error rate.

According to a fifth feature of the invention, the communication link includes an external network and the step of determining error characteristics information comprises the step of receiving quality of service information from the external network and determining the error characteristics information in response to this quality of service information. Preferably, the external network is a TIPHON network and the quality of service information comprises information of whether a terminating network supporting the endpoint terminal is a mobile wireless network.

According to a sixth feature of the invention, the step of determining error characteristics information comprises determining if Transcoder Free Operation is used for communication between the wireless user equipment and the endpoint terminal, and if so determining that the endpoint terminal is a second wireless user equipment and setting the error characteristics information accordingly.

According to a seventh feature of the invention, the step of determining error characteristics information comprises determining if Tandem Free Operation is used for communication between the wireless user equipment and the endpoint terminal, and if so determining that the endpoint terminal is a second wireless user equipment and setting the error characteristics information accordingly.

According to a eighth feature of the invention, the step of determining error characteristics information comprises determining if setup of a communication between the wireless user equipment and the endpoint terminal includes a Mobile Switch Centre accessing a Home Location Register, and if so determining that the endpoint terminal is a second wireless user equipment, and setting the error characteristics information accordingly.

According to a ninth feature of the invention, the step of determining error characteristics information comprises analysing call setup messages to determine if the identity of the endpoint terminal corresponds to an identity of a wireless user equipment, and setting the error characteristics information accordingly.

These features provide different low complexity methods of determining if radio links are included in the communication links. The methods are compatible with the standards of the main cellular communication systems currently used or under development therefore having the advantage of not requiring changes in the standard specifications for these systems.

According to a second aspect of the invention, there is provided a communication network for a cellular communication system supporting wireless user equipment over a radio link for communication with an endpoint terminal, the method comprising the steps of: means for determining error characteristics information associated with a communication link to the endpoint terminal; and means for setting an error rate of the radio link in response to the determined error characteristics information associated with the communication link.

## Brief Description of the Drawings

An embodiment of the invention will be described, by way of example only, with reference to the drawings, in which

FIG 1. is an illustration of a cellular communication system in accordance with the prior art;

FIG. 2 is an illustration of a communication system in accordance with an embodiment of the invention;

FIG. 3 illustrates a scenario of the embodiment of FIG. 2 wherein the endpoint terminal is a wireless user equipment;

FIG. 4 illustrates a scenario of the embodiment of FIG. 2 wherein the endpoint terminal is fixed landline telephone; and

FIG. 5 is an illustration of a flowchart for a method of setting an error rate in accordance with an embodiment of the invention.

## Detailed Description of a Preferred Embodiment of the Invention

In the following a preferred embodiment of the invention is described with reference to a WCDMA communications system, however the invention can be applied to any suitable communication systems including systems such as GSM, IS95 or UMTS TDD.

In a UMTS CDMA communication system, the communication network comprises a core network and a Radio Access Network (RAN). The core network is operable to route data from one part of the RAN to another, as well as interfacing with other communication systems. In addition, it performs many of the operation and management functions of a cellular communication system, such as billing. The RAN is operable to support wireless user equipment over a radio link being part of the air interface. The wireless user equipment may be a mobile station, a communication terminal, a personal digital assistant, a laptop computer, an embedded communication processor or any communication element communicating over the air interface. The RAN comprises the base stations known as

Node Bs, as well as Radio Network Controllers (RNC) which control the Node Bs and the communication over the air interface.

Upon call or connection set up in a CDMA radio access based system, the RAN is provided with a frame erasure or frame error rate (FER) based target. This target is in conventional systems based only on the service type requested, and is used as a target by the transmit power control loops. For example, for a voice call, it may be sufficient to set the radio channel's FER to an average of 2%to achieve the necessary quality.

FIG. 2 is an illustration of a communication system in accordance with an embodiment of the invention. For clarity, the figure only includes elements necessary to describe the embodiment, and a typical communication system will comprise many other elements, including other user equipment, base stations, network controllers, network elements, switches, routers etc.

A wireless user equipment 201 is supported by a base station 203 over a radio link 205 in order to communicate with an endpoint terminal 207. The endpoint terminal 207 can be any communication entity suitable for communication, including another user equipment, a mobile station, a computer, a landline telephone, a modem. The communication between the user equipment and the endpoint terminal may be a connection based communication, a packet based communication or any other suitable form. The communication may be of any type including for example voice communication, data communication or video conferencing. For simplification, the following description focuses on a connection based voice communication.

The base station is connected to a communication network (not shown) and is communicating with the endpoint terminal 207 through a communication link 209. The communication link 209 does not specifically

include the radio link 205 but will typically include part of the communication network and may also include for example other radio links, gate way elements, other communication systems or other links or connections used for communicating traffic between the user equipment 201 and the endpoint terminal 207.

An error processor 211 is operably coupled to the communication link and is operable to determine error characteristics information associated with a communication link 209 to the endpoint terminal 207. An error controller 213 is connected to the error processor 211 and is operable to set an error rate of the radio link 205 in response to the determined error characteristics associated with the communication link 209.

FIG. 3 and 4 illustrates two possible alternative scenarios for the embodiment of FIG. 2 dependent on the nature of the endpoint terminal 207. Specifically FIG. 3 illustrates a scenario wherein the endpoint terminal 207 is another wireless user equipment and FIG. 4 illustrates a scenario where the endpoint terminal 207 is fixed landline telephone.

In FIG. 3, the communication link comprises the elements of the fixed network 301 involved in routing calls between the user equipment 201 and the endpoint terminal 207, which in this case is a wireless user equipment, such as a mobile telephone. The communication link also comprises the base station 303 supporting the endpoint terminal 207, and a second radio link 305 over which the endpoint terminal 207 is supported.

In FIG. 4, the endpoint terminal 207 is a landline telephone, and the communication link 209 comprises the elements of the fixed network 401 involved in routing calls between the user equipment 201 and a gateway 403 interfacing to the PSTN 405. The PSTN 405 forms the last leg of the connection to the endpoint terminal 207 and is itself part of the communication link 209.

FIG. 5 is an illustration of a flowchart for a method of setting an error rate in accordance with an embodiment of the invention. For clarity, the described embodiment focuses on an implementation wherein the error rate setting occurs at call setup for a user equipment originating call. However, the method can be applied at any time and in particular in connection with a call setup originating anywhere, during a call or prior to a call being setup. In addition, the method may be applied to a connection oriented communication such as the voice call of the preferred embodiment, but is equally applicable to e.g. packet based communication links.

In step 501, the user equipment 201 requests a call setup from the base station 203. The base station 203 communicates with the fixed network, which in step 503 proceeds to setup a connection to the endpoint terminal 207, with which the user equipment is seeking to communicate.

In step 505, the error processor 211 determines error characteristics information associated with a communication link 209 to the endpoint terminal 207. Ideally, the error processor 211 accurately determines an expected error rate for the communication between the base station 203 and the endpoint terminal 207 by individually calculating an error rate for all links involved in forming the connection. However, such a calculation is complex, and it will typically not be possible to accurately evaluate expected error rates.

In the preferred embodiment, a simple form of error characteristics information is used wherein the error processor 211 simply determines if the communication link includes a radio link or only comprises wire links. If the error characteristics information indicates that no radio link is involved in the connection, the error rate can be assumed to be low and in most cases insignificant in comparison to the error rate of the radio link

205. However, if the error characteristics information indicates that a radio link is present, the total error rate of the communication link 209 is likely to be high, and specifically to be comparable to the error rate of the radio link 205. Hence, in an embodiment where communication is made either to another wireless user equipment or to a landline telephone, the error processor 211 determines if the call setup results in the communication link of FIG. 3 or of FIG. 4 being setup.

In step 507, the error controller 213 sets the error rate of the radio link 205 in response to the determined error characteristics associated with the communication link 209. The error rate can be set according to any criterion that will result in the desired communication quality, taking the error characteristics information of the communication link 209 into account. However, in the preferred embodiment the error rate of the radio link 205 is set such that the overall error rate between the wireless user equipment 201 and the endpoint terminal 207 meets a given criterion, and specifically such that the overall error rate from the user equipment 201 to the endpoint terminal 207 on average is below a given threshold. In the ideal case, an accurate error rate of the communication link 209 is known and the error rate of the communication link is set such that the total rate equals a predetermined value. Assuming low error rates, the total error rate is approximately equal to the sum of the error rate of the communication link 209 and of the radio link 205, and thus the error rate of the radio link 205 is set to the desired overall error rate minus the error rate of the communication link 209.

In the preferred embodiment, where the error characteristics information simply indicates whether the communication link 209 comprises a radio link or not, the error rate is simply set to a first value if a radio link is included, and to a second higher value if it is not included. As a specific example, a voice call is generally acceptable with Frame Erasure or Error Rates (FER) up to approximately 2%. The error rate for wireline

connections is much lower and therefore insignificant. Hence, the total error rate of the connection is almost exclusively due to the error rates of any radio links. If the communication link 209 does not include a second radio link, the only radio link involved in the communication is that between the user equipment 201 and the base station 203. Consequently, the error rate of the radio link is set to a FER of 2%. However, if the communication link 209 does include a second radio link, two radio links having high error rates are included in the connection, and the error rate of the radio link 205 between the user equipment 201 and base station 203 will be set to half the total rate, i.e. to 1 %. Hence, in the preferred embodiment, the higher error rate, when the communication link 209 does not include a radio link, is set to approximately twice the lower rate, when a second radio link is included. Typically, a ratio between the higher and lower error rate of between 1.5 and 3 will be appropriate.

In step 509 the call is setup and progresses using the determined error rate. The error rate of the radio link 205 is maintained around the desired level by power control loops as is well known in the art.

In the preferred embodiment of a UMTS WBCDMA signal, the error processor 211 and error controller 213 are part of the core network. The core network sets the FER target for the radio link in a call or end to end connection via RANAP (Radio Access Network Application Part) messaging, which is the protocol used for control messages between the core network and the UMTS RAN. The parameters used to describe the quality of service (including FER) and traffic characteristics of a source are described in 3GPP standard 23.107. The core network informs an RNC associated with the base station 203 of the radio bearer requirements using a RANAP (25.413) 'RAB (Radio Access Bearer) assignment request' message. This message contains an information element called 'RAB parameters' which itself contains an information element called 'Service Data Unit (SDU) parameters' in which the SDU error ratio and residual

error rate are defined. The RNC can set the FER target in the mobile using any of the following Radio Resource Control (RRC) messages: Radio bearer set-up, Radio Bearer Reconfiguration, Transport Channel Reconfiguration, Physical Channel Reconfiguration. Similar messages exist in the Node B Application Part (NBAP) specification by which the RNC can inform the base stations (Node B's) of the FER targets, which should be used in order to perform power control.

In conventional systems, the error rate of the radio link is set independently of the nature of the communication link supporting the endpoint terminal. Hence, if the error rate of the radio link is set equivalent to the total desired error rate, the actual achieved overall error rate will be higher when the communication link includes a high error rate link, such as a second radio link. Conversely, if the error rate is set roughly equal to half the desired overall error rate, the resultant overall error rate will be significantly lower than necessary when no high error rate links are included in the communication link. Thus, in this case, more than necessary transmit power will be applied which wastes resource in a cell and increases interference.

Hence, by using the described method, a highly efficient method of setting the error rate of the radio link depending on the characteristics of the communication link to the endpoint terminal is achieved. This significantly saves resource used by the radio link, thereby improving the capacity of the cellular communication system.

The error characteristics information can be any information that can be used to derive an indication of the error performance of the communication link or part of the communication link. As such, it includes information relating to the actual error performance of any element of the communication link, to the nature of any element of the communication link, the nature of the endpoint terminal or to whether the communication

link includes specific elements. As such, it is also within the contemplation of the invention, that the steps of determining the error characteristics information and setting the error rate may be integrated and be performed in a single operation. The error characteristics information may therefore in some embodiments not be explicitly derived but may be implicitly determined as part of the operation of setting the error rate of the radio communication link.

In some embodiments of the invention, the error processor determines the error characteristics information from a determination of the nature of the endpoint terminal. In these embodiments, the error processor determines if the endpoint terminal is a wireless user equipment. If the endpoint terminal is determined as a wireless user equipment such as a mobile station or mobile telephone, the error processor concludes that it is supported over a second radio link, and it thus sets the error characteristics information to indicate that the communication link includes a second radio link.

In the following, different methods for determining the nature of the endpoint terminal will be described. Although the methods are described in different embodiments of the invention, it is within the contemplation of the invention that a given embodiment may comprise two or more of the described methods.

In one embodiment, the error processor determines if Transcoder Free Operation (TrFO) is used for communication between the wireless user equipment and the endpoint terminal. If so, the endpoint terminal is a second wireless user equipment, and the error characteristics information will be set accordingly.

In another embodiment, the error processor determines if Tandem Free Operation(TFO) is used for communication between the wireless user

equipment and the endpoint terminal. If so, it is determined that the endpoint terminal is a second wireless user equipment, and the error characteristics information is set to reflect this.

In a network where TFO is not enabled, a transcoder in the wireless station compresses speech to a form more compatible with transmission over a bandwidth limited radio link. In the fixed part of the mobile communications network, the speech signal is decompressed in a transcoder into a form suitable for onward transmission.This form usually encodes the speech as a digital pulse code modulated signal (PCM), for example as defined in ITU-T (International Telecommunications Union) recommendation G.711. If the onward transmission is towards a second wireless terminal, the PCM signal is again transcoded into the compressed form suitable for transmission over a radio link. The received signal in the wireless station is finally decompressed to form a speech signal to present to the end user.

TFO avoids the extra decompression and compression operations in the fixed network. In so doing the quality of the speech signal received at the second wireless station may be significantly improved, because transcoding operations can reduce speech quality. To to this, TFO uses a signalling channel which steals a small amount of the bandwidth allocated for the speech signal within the fixed network. This signalling is used both to allow the detection of TFO-compliant equipment and to control the TFO operation. If the protocol decides that TFO is possible, the two TFO-compliant fixed network transcoders disable their transcoder functions and become transparent, passing the compressed speech signals unchanged.

Since TFO signalling uses the speech path (the so-called bearer plane), any network equipment which may normally alter the bearer plane signal (e.g. echo cancellers), must become transparent on TFO being invoked.

This means that such equipment must be designed with TFO in mind. An alternative approach, Transcoder Free Operation (TrFO) avoids this by undertaking all related signalling in the control plane, leaving the bearer plane untouched. Additionally, it operates by re-routing the bearer plane around equipment that alters the bearer plane signal (e.g. transcoders, echo cancellers), so that the latter equipment does not have to be redesigned to be TrFO compliant.

In both cases (TFO, TrFO), the system at each end (and specifically the error processor) is aware that both endpoints are wireless stations, and will set the error rate accordingly.

In accordance with the TrFO embodiment, the error processor thus detects if signalling occurs to setup or control TrFO for the wireless user equipment supported over the radio link. The signalling for TrFO is core network signalling, and in this embodiment the error processor is therefore preferably part of the core network. If TrFO signalling is detected, the endpoint terminal must be a second wireless user equipment engaging in a voice call with the user equipment. Consequently, the communication link will include a second radio link and the error characteristics information is set to reflect this.

In the TFO embodiment, the error processor can thus detect that TFO in-band signalling occurs, and therefrom conclude that the endpoint terminal is a second user equipment. Additionally or alternatively for the TFO or TrFO embodiments, the error processor may be coupled to other network elements which may detect TFO mode and inform the error processor. Specifically, the error processor may be connected to one or more of the network transcoders.

In another embodiment, the error processor determines if setup of a communication between the wireless user equipment and the endpoint

terminal includes a Gateway Mobile Switch Centre accessing a Home Location Register. If so, it determines that the endpoint terminal is a second wireless user equipment, and it sets the error characteristics information accordingly.

If the call is being made between two wireless user equipment supported by a cellular communication network, the call setup procedure includes a Mobile Switch Center (MSC) of the communication network accessing a Home Location Register in order to determine how to access the called user equipment. As the called user equipment in this scenario is a mobile device, the serving base station will vary over time as the user equipment moves in the network. Each user equipment is associated with an HLR, wherein information is stored enabling the network to call a user equipment. Therefore, if the called entity is a user equipment, the call setup process will include accessing an HLR. However, if the call is not to a user equipment of the communication system, but to e.g. a landline terminal accessed through a gateway, the call setup procedure will not include accessing an HLR.

Specifically, in one embodiment an MSC comprising gateway functions will have an associated error processor, which for every new call setup message detects if the MSC accesses the HLR. As the MSC has Gateway functionality, it will need to access the HLR, if the called party is a user equipment. If the called party is a landline telephone, it will route the call setup through the gateway without accessing the HLR. Hence, if the error processor detects that the call setup message results in the MSC polling an HLR, it will determine that the endpoint terminal is a wireless user equipment, and otherwise it will determine that the endpoint terminal is not a wireless user equipment.

In another embodiment, the call setup messages are analysed to determine if the identity of the endpoint terminal corresponds to an

identity of a wireless user equipment, and to set the error characteristics information accordingly.

Specifically, in the case of a wireless user equipment originating call, the error processor determines if a Calling Line Identity of the endpoint terminal corresponds to an identity of a wireless user equipment. If so, it sets the error characteristics information to reflect this.

Thus in the situation where the call is instigated by the endpoint terminal, the call setup messages for the user equipment comprises a Calling Line Identity (CLI) field, which contains the public address with which the endpoint terminal can be reached. This includes the telephone number if the endpoint terminal is a mobile telephone or landline telephone. Analysis of this field can determine the source network of the call. As the number plan for virtually all communication systems follow the standardised E.164 number plan, the error processor can determine if the call originated in a mobile communication system, and thus that the endpoint terminal is a wireless user equipment.

In the case of a wireless user equipment originating call, the call setup messages comprise a Destination Address (DA) of the called party, i.e. of the endpoint terminal. This field can be analysed as described for the CLI field to determine if the destination network is a mobile network, and thus if the endpoint terminal is a wireless user equipment.

The above embodiments describe different methods for detecting if the call is between two wireless user equipments, and if so it sets the error characteristics information to reflect this directly, or to indicate that a second radio link is included in the communication link. Each method is operable to detect that the endpoint terminal is a wireless user terminal in some circumstances. As these circumstances are different for different methods, the preferred embodiment employs all methods in parallel,

although it is within the contemplation of the invention that any combination of the described methods or any other methods of determining the error characteristics information of the communication link can be used.

In some embodiments of the invention, the communication link may include an external network not part of the cellular communication system. For example the communication link can include a PSTN or an Internet Protocol (IP) based network connecting to the endpoint terminal.

In one of these embodiments, the error processor receives quality of service information from the external network, and determines the error characteristics information in response to this quality of service information. Specifically, in one of these embodiments, the external network is a TIPHON (Telecommunications and Internet Protocol Harmonization Over Networks) network standardised by the European Telecommunication Standards Institute (ETSI). TIPHON networks comprise protocols for exchanging and negotiating quality of service between different network domains (sub-networks).

Thus for an external TIPHON network, the core network of the communication system will negotiate or at least be informed of the error rate Quality of Service (QoS) parameter. This parameter is forwarded to the error processor and included in the error characteristics information. In one specific embodiment, the external TIPHON network simply informs the error processor of whether the terminating network supporting the endpoint terminal is a mobile wireless network or not.

The described embodiments have focussed on a connection based communication. However, the invention is equally applicable to a packet based network wherein the error characteristics information may refer to a single packet, to a stream of packets or to any other aspect of the

communication link affecting the error performance of the communication to the endpoint terminal.

It will be clear, that the invention is equally applicable to communication originating at the user equipment or at the endpoint terminal. In the preferred embodiment, the error rate of all radio links are set in accordance with the invention. Thus specifically for a voice call between two wireless user equipment, the error rate for both radio links are set in accordance with the invention.

Likewise, it is clear that the invention is equally applicable uplink and downlink communication.

The invention can be implemented in any suitable form including hardware, software, firmware or any combination of these. However, preferably, the invention is implemented as computer software running on one or more data processors. The elements and components of an embodiment of the invention may be located in the core network, the radio access network or any suitable physical or functional location. Indeed the functionality may be implemented in a single unit, in a plurality of units or as part of other functional units. As such, the invention may be implemented in a single unit or may be physically and functionally distributed in the network.

It will be clear, that the invention tends to provide a number of advantages, singly or in combination, including the following:

- Optimisation of error rate on a radio link thereby optimising resource usage and capacity of the communication system.
- Low complexity system for optimising the error rate of a radio link in response to the characteristics of the entire communication link.

- Low complexity and efficient system for determining if more than one radio link is involved, and optimising the error rate accordingly

## Claims

1. A method of setting an error rate in a cellular communication system supporting wireless user equipment over a radio link for communication with an endpoint terminal, the method comprising the steps of:

determining error characteristics information associated with a communication link to the endpoint terminal; and

setting an error rate of the radio link in response to the determined error characteristics information associated with the communication link.

2. A method as claimed in claim 1 wherein the step of setting the error rate comprises setting the error rate of the radio link such that an overall error rate between the wireless user equipment and the endpoint terminal meets a given criterion.

3. A method as claimed in claim 3 wherein the criterion is that the overall error rate on average is below a given threshold.

4. A method as claimed in any of the previous claims wherein the error characteristics information comprises information of whether the communication link includes a second radio link.

5. A method as claimed in claim 4 wherein the step of determining error characteristics information of the communication link comprises the step of determining if the endpoint terminal is a wireless user equipment supported over the second radio link.

6. A method as claimed in claim 4 or 5 wherein the step of setting the error rate comprises setting the error rate of the radio link at a lower error rate when the communication link includes the second radio link and at a

higher error rate when the communication link does not include the second radio link.

7. A method as claimed in claim 6 wherein the higher error rate is substantially twice the lower error rate.

8. A method as claimed in any of the previous claims wherein the communication link includes an external network and the step of determining error characteristics information comprises the step of receiving quality of service information from the external network and determining the error characteristics information in response to this quality of service information.

9. A method as claimed in claim 8 wherein the external network is a TIPHON network and the quality of service information comprises information of whether a terminating network supporting the endpoint terminal is a mobile wireless network.

10. A method as claimed in any previous claim wherein the step of determining error characteristics information comprises determining if Transcoder Free Operation is used for communication between the wireless user equipment and the endpoint terminal, and if so determining that the endpoint terminal is a second wireless user equipment and setting the error characteristics information accordingly.

11. A method as claimed in any previous claim wherein the step of determining error characteristics information comprises determining if Tandem Free Operation is used for communication between the wireless user equipment and the endpoint terminal, and if so determining that the endpoint terminal is a second wireless user equipment and setting the error characteristics information accordingly.

12. A method as claimed in any previous claim wherein the step of determining error characteristics information comprises determining if setup of a communication between the wireless user equipment and the endpoint terminal includes a Mobile Switch Centre accessing a Home Location Register, and if so determining that the endpoint terminal is a second wireless user equipment, and setting the error characteristics information accordingly.

13. A method as claimed in any previous claim wherein the step of determining error characteristics information comprises analysing call setup messages to determine if the identity of the endpoint terminal corresponds to an identity of a wireless user equipment, and setting the error characteristics information accordingly.

14. A communication network for a cellular communication system supporting wireless user equipment over a radio link for communication with an endpoint terminal, the method comprising the steps of:

means for determining error characteristics information associated with a communication link to the endpoint terminal; and

means for setting an error rate of the radio link in response to the determined error characteristics information associated with the communication link.

15. A communication network as claimed in claim 14 wherein means for setting the error rate is operable to set the error rate of the radio link such that an overall error rate between the wireless user equipment and the endpoint terminal meets a given criterion.

16. A communication network as claimed in claim 15 wherein the criterion is that the overall error rate on average is below a given threshold.

17. A communication network as claimed in any of the previous claims 14 to 16 wherein the error characteristics information comprises information of whether the communication link includes a second radio link.

18. A communication network as claimed in claim 17 wherein means for determining error characteristics information of the communication link is operable to determine if the endpoint terminal is a wireless user equipment supported over the second radio link.

19. A communication network as claimed in claim 17 or 18 wherein the means for setting the error rate is operable to set the error rate of the radio link at a lower error rate when the communication link includes the second radio link and at a higher error rate when the communication link does not include the second radio link.

20. A communication network as claimed in claim 19 wherein the higher error rate is substantially twice the lower error rate.

21. A communication network as claimed in any of the previous claims 14 to 20 wherein the communication link includes an external network and the means for determining error characteristics information is operable to receive quality of service information from the external network and determine the error characteristics information in response to this quality of service information.

22. A communication network as claimed in claim 21 wherein the external network is a TIPHON network and the quality of service information comprises information of whether a terminating network supporting the endpoint terminal is a mobile wireless network.

23. A communication network as claimed in any previous claim 14 to 22 wherein the means for determining error characteristics information is operable to determine if Transcoder Free Operation is used for communication between the wireless user equipment and the endpoint terminal, and if so to determine that the endpoint terminal is a second wireless user equipment and to set the error characteristics information accordingly.

24. A communication network as claimed in any previous claim wherein the means for determining error characteristics information is operable to determine if Tandem Free Operation is used for communication between the wireless user equipment and the endpoint terminal, and if so to determine that the endpoint terminal is a second wireless user equipment and to set the error characteristics information accordingly.

25. A communication network as claimed in any previous claim wherein the means for determining error characteristics information is operable to determine if setup of a communication between the wireless user equipment and the endpoint terminal includes a Mobile Switch Centre accessing a Home Location Register, and if so to determine that the endpoint terminal is a second wireless user equipment, and to set the error characteristics information accordingly.

26. A communication network as claimed in any previous claim wherein the means for determining error characteristics information is operable to analyse call setup messages to determine if the identity of the endpoint terminal corresponds to an identity of a wireless user equipment and to set the error characteristics information accordingly.

27. A method of setting an error rate in a cellular communication system substantially as hereinabove described with reference to or as shown in FIGs. 2 to 5 of the drawings.

28. A communication network for a cellular communication system substantially as hereinabove described with reference to or as shown in FIGs. 2 to 5 of the drawings.

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**Claims searched:** All **Date of search:** 14 November 2002

# Patents Act 1977
# Search Report under Section 17

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): H4L(LDTP, LDXX, LFMA, LFMX, LFND, LRAA, LRAB)

Int Cl (Ed.7): H04B1/10, H04B7/005, H04L1/00, H04Q7/(20, 30, 34, 38)

Other: Online: EPODOC, WPI, JAPIO

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | | Relevant to claims |
|---|---|---|---|
| X | EP 1154667 A2 | (Lucent Technologies, Inc.): see whole document, particularly cols. 16 & 18 | 1-5, 14-18 |
| X | EP 0548939 A2 | (NEC Corporation): see whole document, particularly col. 8, lines 43-52 & col. 9, lines 30-88 | 1-5, 12, 14-18, 25 |
| X | US 2001/0019589 | (Il & Hyung): see whole document, particularly abstract & fig. 1 | 1, 14 |
| X | US 6038452 | (Nortel Networks Corp.): see whole document, particularly col. 2, line 38 - col. 3, line 28 & fig. 1 | 1-6, 8, 12-19, 21, 25, 26 |
| X | JP 2002010362 A | (Matsushita Electric Ind. Co. Ltd.): see abstract | 1, 14 |

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